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In operando studies of ScYSZ electrolyte supported symmetric solid oxide cell by X-ray Diffraction at ESRF, ID06 Beamline

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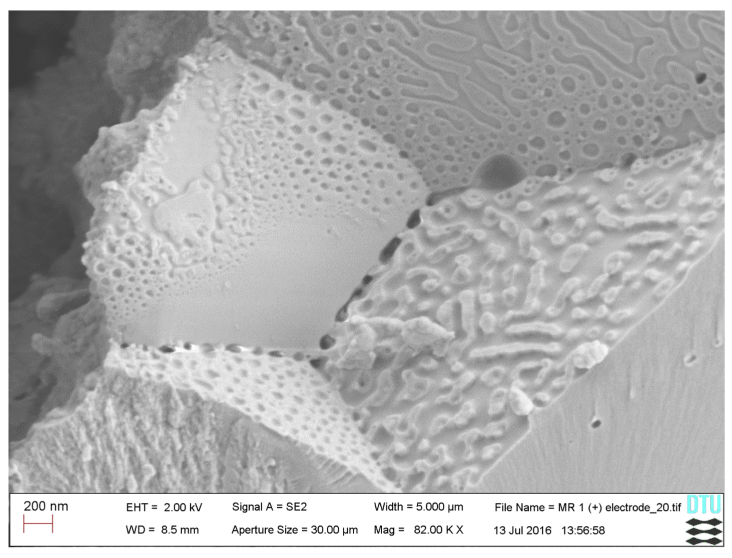
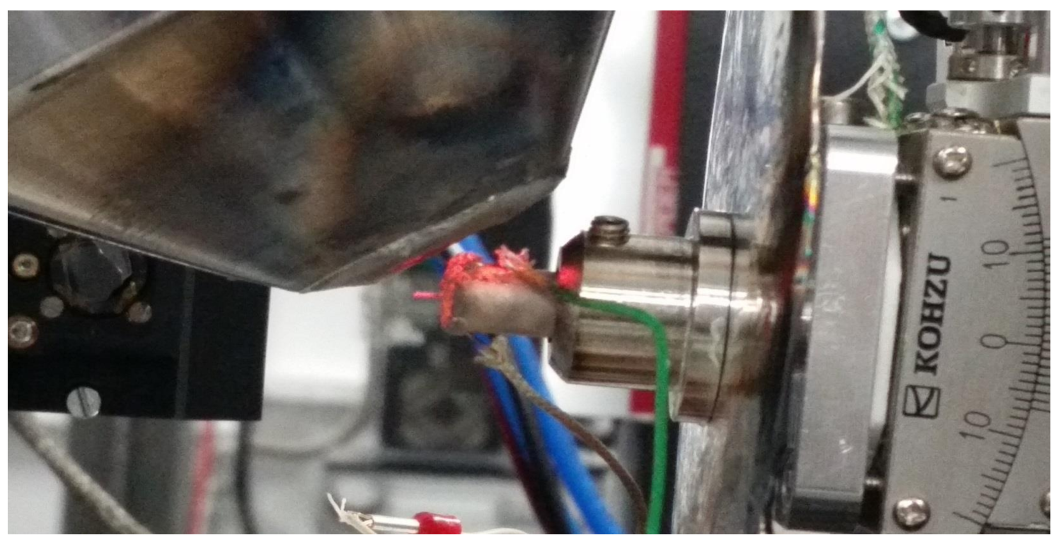
Introduction

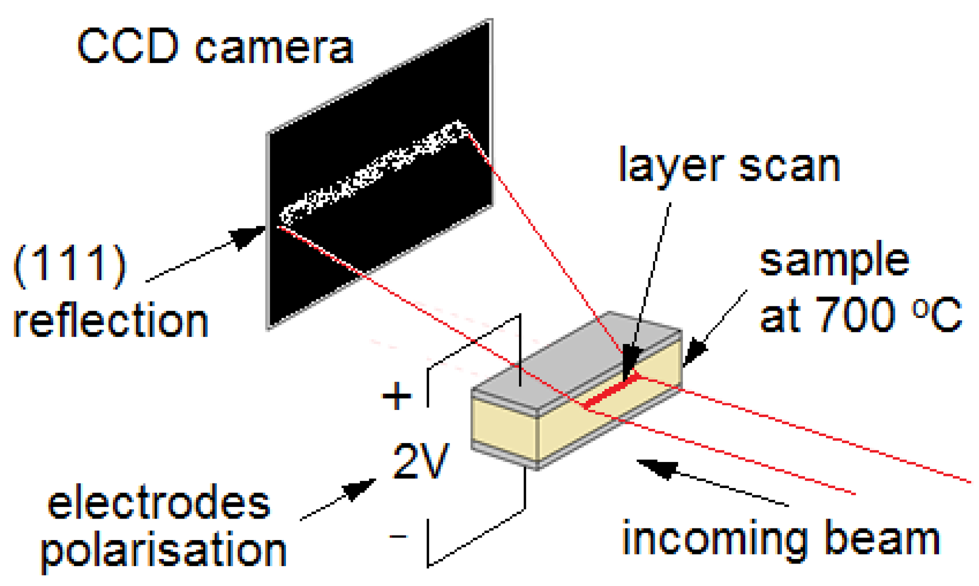
Solid Oxide Cells are becoming a promising solution for sustainable and renewable power generation. Scandium doped Yttria Stabilized Zirconia is considered one of the best materials used as electrolyte because of its high ionic conductivity and great mechanical and chemical stability under operating conditions. Oxygen bubble formation at grain boundaries of ScYSZ near the anode/electrolyte interface has been observed as a degradation process when running in electrolysis mode at 800 - 900 ºC for 24 - 72 hours at high current densities. X-ray diffraction can provide information about structural evolution at different depths of the cell during operation.



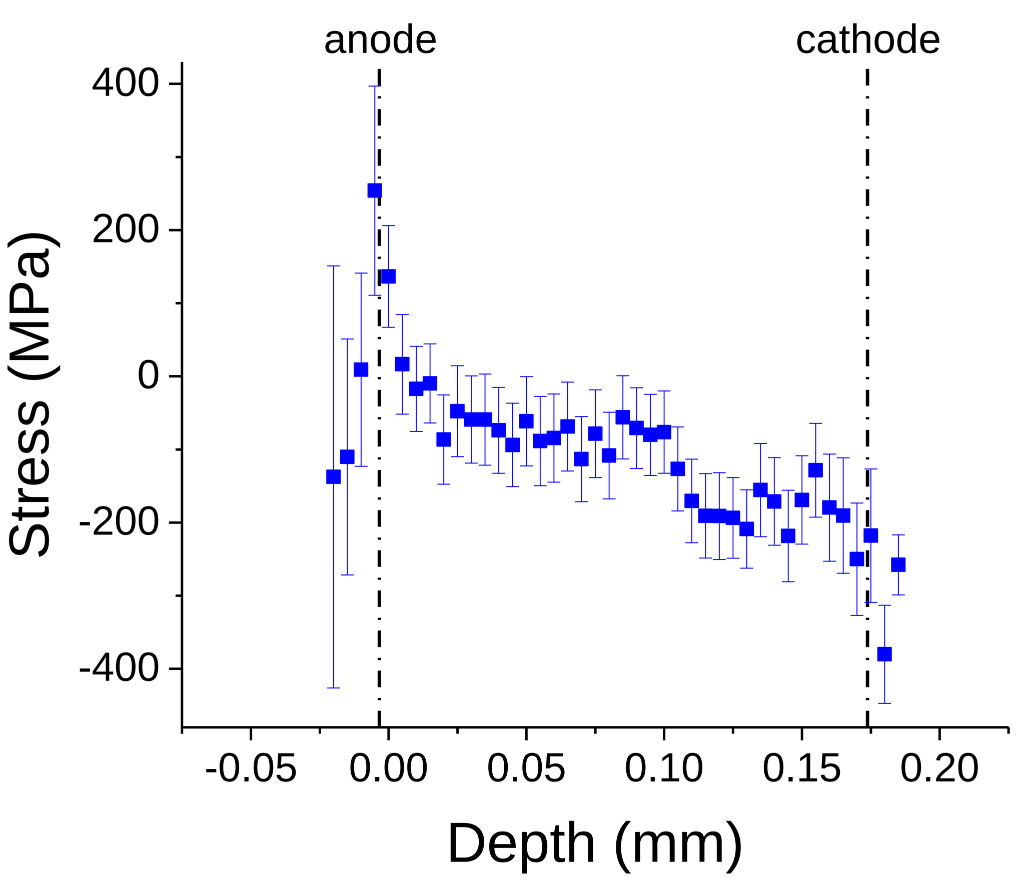
Structural evolution and oxygen bubble formation

Setup of the synchrotron beamline hutch at ESRF - ID06 Beamline:

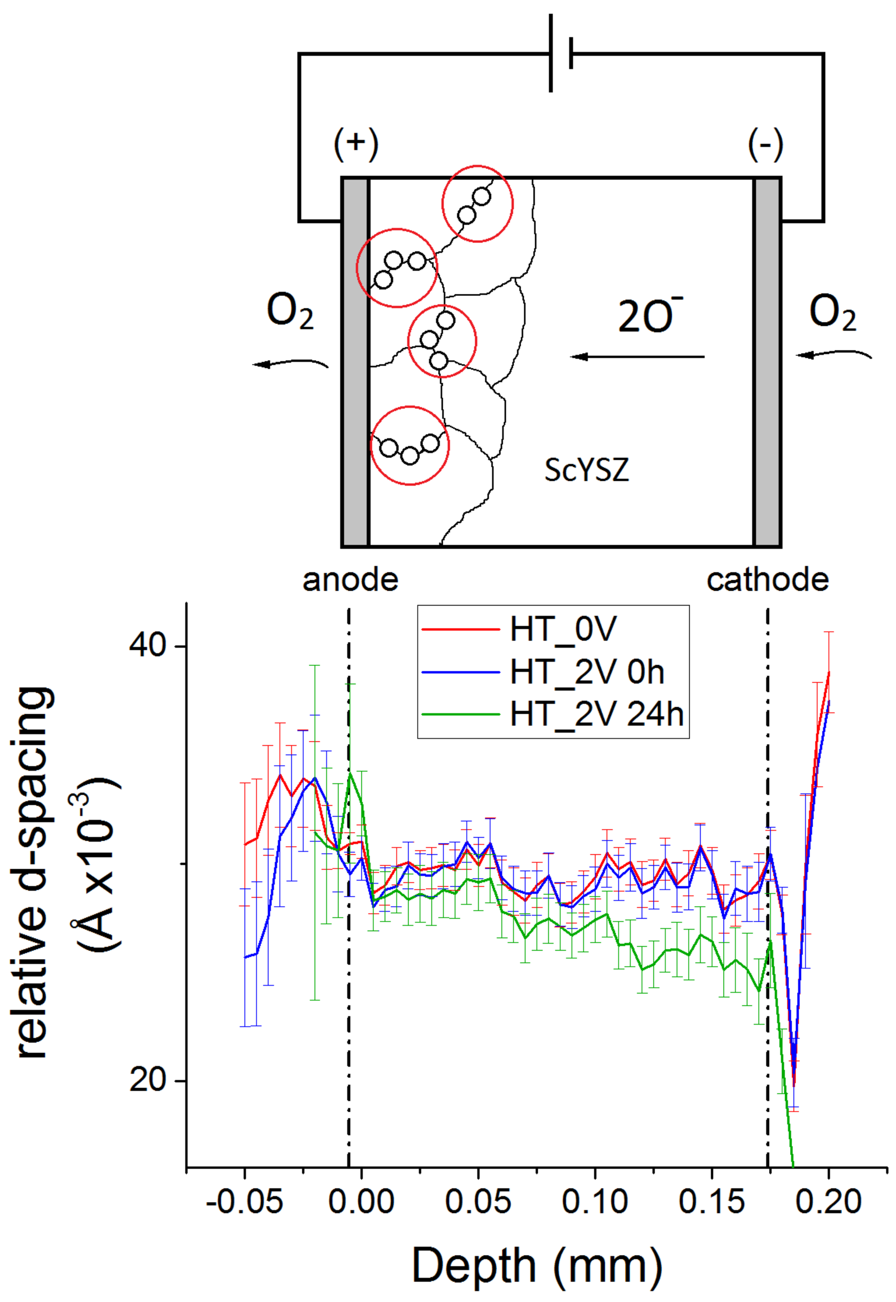




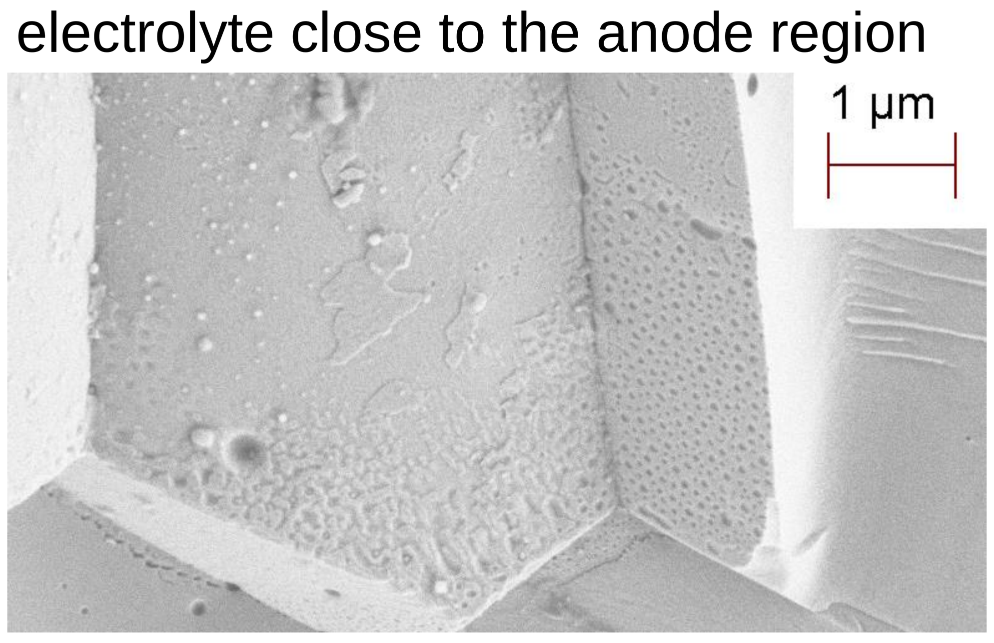
Estimated stress across the cell only from Δd-spacing



Relative d-spacing of (111) diffraction line across the cell and schematic view of the cell polarization and bubbles found.

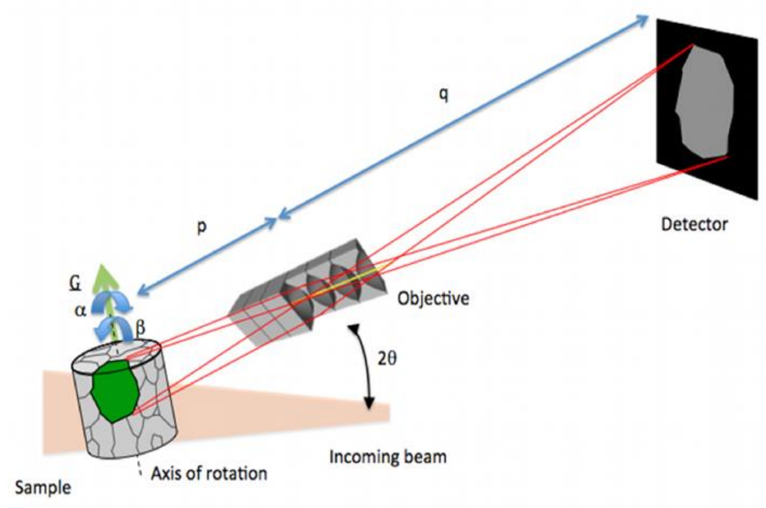


Oxygen bubble formation in electrolyte close to the anode region



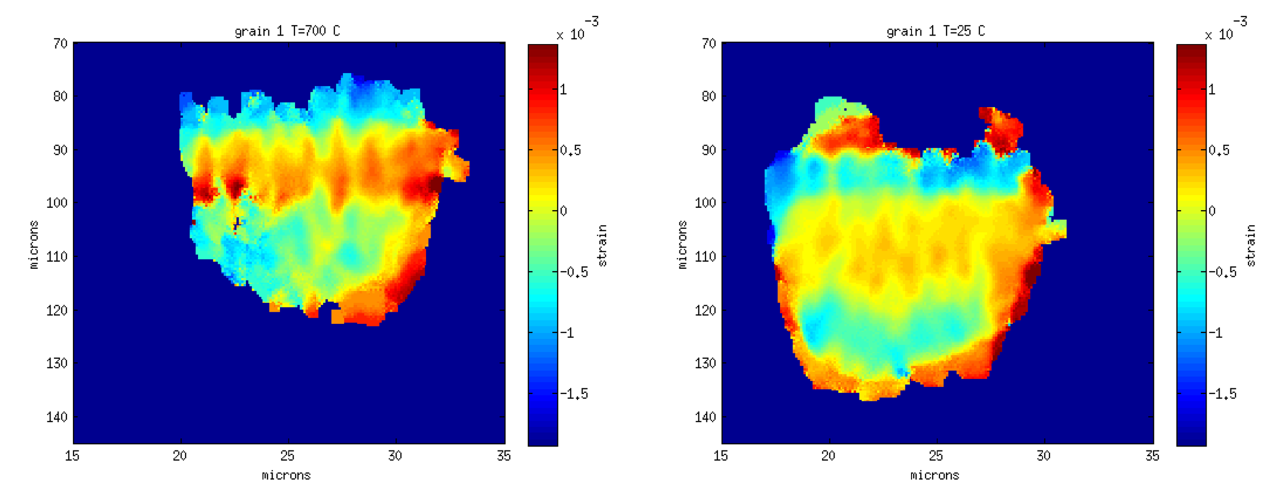
Dark Field X-Ray Diffraction Microscopy

At ID06 beamline we are currently commissioning a dark field microscope, which enables zooming in on mm-sized samples and perform 3D mapping of grains and stresses at a 100 nm scale in regions of 200 µm. This provides unprecedented opportunities for studying microstructural changes in operando materials.

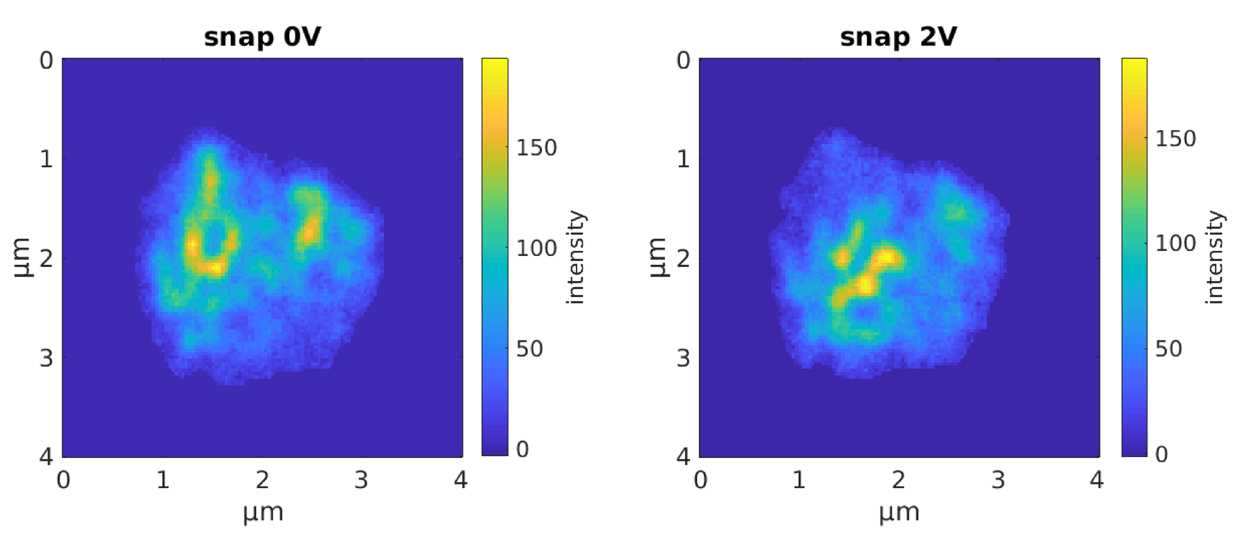


An objective lens composed of several beryllium lenses magnifies the projection of a diffracting grain.

Strain map



In another experiment run at 900 ºC, snapshots at 0V and 2V were taken with an interval of few seconds. The internal processes of the electrolyte grains are unknown, further investigations are expected to provide more information.



Results

A gradient in d-spacing is observed across the cell after 24 hours, which can be a contribution from the oxygen bubble formation and a phase change from the zirconia reduction. X-ray microscopy revealed changes in the morphology and strain domains inside one grain after 10 hours running at operating conditions. Snapshots show changes in the internal structure when the current is applied.

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